

(b) The quality assurance criteria of appendix A to this part must be implemented for all PAMS.

§ 58.45 PAMS data submittal.

(a) The requirements of this section apply only to those stations designated as PAMS by the network description required by § 58.40.

(b) All data shall be submitted to the Administrator in accordance with the format, reporting periods, reporting deadlines, and other requirements as specified for NAMS in § 58.35.

(c) The State shall report NO and NO_x data consistent with the requirements of § 58.35 for criteria pollutants.

(d) The State shall report VOC data and meteorological data within 6 months following the end of each quarterly reporting period.

§ 58.46 System modification.

(a) Any proposed changes to the PAMS network description will be evaluated during the annual SLAMS Network Review specified in § 58.20. Changes proposed by the State must be approved by the Administrator. The State will be allowed 1 year (until the next annual evaluation) to implement the appropriate changes to the PAMS network.

(b) PAMS network requirements are mandatory only for serious, severe, and extreme O₃ nonattainment areas. When any such area is redesignated to attainment, the State may revise its PAMS monitoring program subject to approval by the Administrator.

Subpart F—Air Quality Index Reporting

§ 58.50 Index reporting.

(a) The State shall report to the general public on a daily basis through prominent notice an air quality index in accordance with the requirements of appendix G to this part.

(b) Reporting must commence by January 1, 1981, for all urban areas with a population exceeding 500,000, and by January 1, 1983, for all urban areas with a population exceeding 200,000.

(c) The population of an urban area for purposes of index reporting is the

most recent U.S. census population figure as defined in § 58.1 paragraph (s).

[44 FR 27571, May 10, 1979, as amended at 51 FR 9586, Mar. 19, 1986. Redesignated at 58 FR 8467, Feb. 12, 1993]

Subpart G—Federal Monitoring

SOURCE: 44 FR 27571, May 10, 1979. Redesignated at 58 FR 8467, Feb. 12, 1993.

§ 58.60 Federal monitoring.

The Administrator may locate and operate an ambient air monitoring station if the State fails to locate, or schedule to be located, during the initial network design process or as a result of the annual review required by § 58.20(d):

(a) A SLAMS at a site which is necessary in the judgment of the Regional Administrator to meet the objectives defined in appendix D to this part, or

(b) A NAMS at a site which is necessary in the judgment of the Administrator for meeting EPA national data needs.

§ 58.61 Monitoring other pollutants.

The Administrator may promulgate criteria similar to that referenced in subpart B of this part for monitoring a pollutant for which a National Ambient Air Quality Standard does not exist. Such an action would be taken whenever the Administrator determines that a nationwide monitoring program is necessary to monitor such a pollutant.

APPENDIX A TO PART 58—QUALITY ASSURANCE REQUIREMENTS FOR STATE AND LOCAL AIR MONITORING STATIONS (SLAMS)

1. General Information.

1.1 This appendix specifies the minimum quality assurance/quality control (QA/QC) requirements applicable to SLAMS air monitoring data submitted to EPA. State and local agencies are encouraged to develop and maintain quality assurance programs more extensive than the required minimum.

1.2 To assure the quality of data from air monitoring measurements, two distinct and important interrelated functions must be performed. One function is the control of the measurement process through broad quality assurance activities, such as establishing policies and procedures, developing data

quality objectives, assigning roles and responsibilities, conducting oversight and reviews, and implementing corrective actions. The other function is the control of the measurement process through the implementation of specific quality control procedures, such as audits, calibrations, checks, replicates, routine self-assessments, etc. In general, the greater the control of a given monitoring system, the better will be the resulting quality of the monitoring data. The results of quality assurance reviews and assessments indicate whether the control efforts are adequate or need to be improved.

1.3 Documentation of all quality assurance and quality control efforts implemented during the data collection, analysis, and reporting phases is important to data users, who can then consider the impact of these control efforts on the data quality (see reference 1 of this appendix). Both qualitative and quantitative assessments of the effectiveness of these control efforts should identify those areas most likely to impact the data quality and to what extent.

1.4 Periodic assessments of SLAMS data quality are required to be reported to EPA. To provide national uniformity in this assessment and reporting of data quality for all SLAMS networks, specific assessment and reporting procedures are prescribed in detail in sections 3, 4, and 5 of this appendix. On the other hand, the selection and extent of the QA and QC activities used by a monitoring agency depend on a number of local factors such as the field and laboratory conditions, the objectives for monitoring, the level of the data quality needed, the expertise of assigned personnel, the cost of control procedures, pollutant concentration levels, etc. Therefore, the quality system requirements, in section 2 of this appendix, are specified in general terms to allow each State to develop a quality assurance program that is most efficient and effective for its own circumstances while achieving the Ambient Air Quality Programs data quality objectives.

2. *Quality System Requirements.*

2.1 Each State and local agency must develop a quality system (reference 2 of this appendix) to ensure that the monitoring results:

- (a) Meet a well-defined need, use, or purpose.
- (b) Satisfy customers' expectations.
- (c) Comply with applicable standards specifications.
- (d) Comply with statutory (and other) requirements of society.
- (e) Reflect consideration of cost and economics.
- (f) Implement a quality assurance program consisting of policies, procedures, specifications, standards, and documentation necessary to:
 - (1) Provide data of adequate quality to meet monitoring objectives, and

- (2) Minimize loss of air quality data due to malfunctions or out-of-control conditions. This quality assurance program must be described in detail, suitably documented in accordance with Agency requirements (reference 4 of this appendix), and approved by the appropriate Regional Administrator, or the Regional Administrator's designee. The Quality Assurance Program will be reviewed during the systems audits described in section 2.5 of this appendix.

2.2 Primary requirements and guidance documents for developing the quality assurance program are contained in references 2 through 7 of this appendix, which also contain many suggested and required procedures, checks, and control specifications. Reference 7 of this appendix describes specific guidance for the development of a QA Program for SLAMS. Many specific quality control checks and specifications for methods are included in the respective reference methods described in part 50 of this chapter or in the respective equivalent method descriptions available from EPA (reference 8 of this appendix). Similarly, quality control procedures related to specifically designated reference and equivalent method analyzers are contained in the respective operation or instruction manuals associated with those analyzers. Quality assurance guidance for meteorological systems at PAMS is contained in reference 9 of this appendix. Quality assurance procedures for VOC, NO_x (including NO and NO₂), O₃, and carbonyl measurements at PAMS must be consistent with reference 15 of this appendix. Reference 4 of this appendix includes requirements for the development of quality assurance project plans, and quality assurance and control programs, and systems audits demonstrating attainment of the requirements.

2.3 Pollutant Concentration and Flow Rate Standards.

2.3.1 Gaseous pollutant concentration standards (permeation devices or cylinders of compressed gas) used to obtain test concentrations for CO, SO₂, NO, and NO₂ must be traceable to either a National Institute of Standards and Technology (NIST) NIST-Traceable Reference Material (NTRM) or a NIST-certified Gas Manufacturer's Internal Standard (GMIS), certified in accordance with one of the procedures given in reference 10 of this appendix.

2.3.2 Test concentrations for O₃ must be obtained in accordance with the UV photometric calibration procedure specified in 40 CFR part 50, appendix D, or by means of a certified ozone transfer standard. Consult references 11 and 12 of this appendix for guidance on primary and transfer standards for O₃.

2.3.3 Flow rate measurements must be made by a flow measuring instrument that is traceable to an authoritative volume or

other applicable standard. Guidance for certifying some types of flowmeters is provided in reference 7 of this appendix.

2.4 National Performance Audit Program (NPAP). Agencies operating SLAMS are required to participate in EPA's NPAP. These audits are described in reference 7 of this appendix. For further instructions, agencies should contact either the appropriate EPA Regional QA Coordinator at the appropriate EPA Regional Office location, or the NPAP Coordinator, Emissions Monitoring and Analysis Division (MD-14), U.S. Environmental Protection Agency, Research Triangle Park, NC 27711.

2.5 Systems Audit Programs. Systems audits of the ambient air monitoring programs of agencies operating SLAMS shall be conducted at least every 3 years by the appropriate EPA Regional Office. Systems audit programs are described in reference 7 of this appendix. For further instructions, agencies should contact either the appropriate EPA Regional QA Coordinator or the Systems Audit QA Coordinator, Office of Air Quality Planning and Standards, Emissions Monitoring and Analysis Division (MD-14), U.S. Environmental Protection Agency, Research Triangle Park, NC 27711.

3. Data Quality Assessment Requirements.

3.0.1 All ambient monitoring methods or analyzers used in SLAMS shall be tested periodically, as described in this section, to quantitatively assess the quality of the SLAMS data. Measurement uncertainty is estimated for both automated and manual methods. Terminology associated with measurement uncertainty are found within this appendix and includes:

(a) Precision. A measurement of mutual agreement among individual measurements of the same property usually under prescribed similar conditions, expressed generally in terms of the standard deviation;

(b) Accuracy. The degree of agreement between an observed value and an accepted reference value, accuracy includes a combination of random error (precision) and systematic error (bias) components which are due to sampling and analytical operations;

(c) Bias. The systematic or persistent distortion of a measurement process which causes errors in one direction. The individual results of these tests for each method or analyzer shall be reported to EPA as specified in section 4 of this appendix. EPA will then calculate quarterly assessments of measurement uncertainty applicable to the SLAMS data as described in section 5 of this appendix. Data assessment results should be reported to EPA only for methods and analyzers approved for use in SLAMS monitoring under appendix C of this part.

3.0.2 Estimates of the data quality will be calculated on the basis of single monitors and reporting organizations and may also be calculated for each region and for the entire

Nation. A reporting organization is defined as a State, subordinate organization within a State, or other organization that is responsible for a set of stations that monitors the same pollutant and for which data quality assessments can be pooled. States must define one or more reporting organizations for each pollutant such that each monitoring station in the State SLAMS network is included in one, and only one, reporting organization.

3.0.3 Each reporting organization shall be defined such that measurement uncertainty among all stations in the organization can be expected to be reasonably homogeneous, as a result of common factors.

(a) Common factors that should be considered by States in defining reporting organizations include:

(1) Operation by a common team of field operators.

(2) Common calibration facilities.

(3) Oversight by a common quality assurance organization.

(4) Support by a common laboratory or headquarters.

(b) Where there is uncertainty in defining the reporting organizations or in assigning specific sites to reporting organizations, States shall consult with the appropriate EPA Regional Office. All definitions of reporting organizations shall be subject to final approval by the appropriate EPA Regional Office.

3.0.4 Assessment results shall be reported as specified in section 4 of this appendix. Table A-1 of this appendix provides a summary of the minimum data quality assessment requirements, which are described in more detail in the following sections.

3.1 Precision of Automated Methods Excluding PM_{2.5}.

3.1.1 Methods for SO₂, NO₂, O₃ and CO. A one-point precision check must be performed at least once every 2 weeks on each automated analyzer used to measure SO₂, NO₂, O₃ and CO. The precision check is made by challenging the analyzer with a precision check gas of known concentration (effective concentration for open path analyzers) between 0.08 and 0.10 ppm for SO₂, NO₂, and O₃ analyzers, and between 8 and 10 ppm for CO analyzers. To check the precision of SLAMS analyzers operating on ranges higher than 0 to 1.0 ppm SO₂, NO₂, and O₃, or 0 to 100 ppm for CO, use precision check gases of appropriately higher concentration as approved by the appropriate Regional Administrator or their designee. However, the results of precision checks at concentration levels other than those specified above need not be reported to EPA. The standards from which precision check test concentrations are obtained must meet the specifications of section 2.3 of this appendix.

3.1.1.1 Except for certain CO analyzers described below, point analyzers must operate

in their normal sampling mode during the precision check, and the test atmosphere must pass through all filters, scrubbers, conditioners and other components used during normal ambient sampling and as much of the ambient air inlet system as is practicable. If permitted by the associated operation or instruction manual, a CO point analyzer may be temporarily modified during the precision check to reduce vent or purge flows, or the test atmosphere may enter the analyzer at a point other than the normal sample inlet, provided that the analyzer's response is not likely to be altered by these deviations from the normal operational mode. If a precision check is made in conjunction with a zero or span adjustment, it must be made prior to such zero or span adjustments. Randomization of the precision check with respect to time of day, day of week, and routine service and adjustments is encouraged where possible.

3.1.1.2 Open path analyzers are tested by inserting a test cell containing a precision check gas concentration into the optical measurement beam of the instrument. If possible, the normally used transmitter, receiver, and as appropriate, reflecting devices should be used during the test, and the normal monitoring configuration of the instrument should be altered as little as possible to accommodate the test cell for the test. However, if permitted by the associated operation or instruction manual, an alternate local light source or an alternate optical path that does not include the normal atmospheric monitoring path may be used. The actual concentration of the precision check gas in the test cell must be selected to produce an effective concentration in the range specified in section 3.1.1. Generally, the precision test concentration measurement will be the sum of the atmospheric pollutant concentration and the precision test concentration. If so, the result must be corrected to remove the atmospheric concentration contribution. The corrected concentration is obtained by subtracting the average of the atmospheric concentrations measured by the open path instrument under test immediately before and immediately after the precision check test from the precision test concentration measurement. If the difference between these before and after measurements is greater than 20 percent of the effective concentration of the test gas, discard the test result and repeat the test. If possible, open path analyzers should be tested during periods when the atmospheric pollutant concentrations are relatively low and steady.

3.1.1.3 Report the actual concentration (effective concentration for open path analyzers) of the precision check gas and the corresponding concentration measurement (corrected concentration, if applicable, for open path analyzers) indicated by the ana-

lyzer. The percent differences between these concentrations are used to assess the precision of the monitoring data as described in section 5.1. of this appendix.

3.1.2 Methods for Particulate Matter Excluding PM_{2.5}. A one-point precision check must be performed at least once every 2 weeks on each automated analyzer used to measure PM₁₀. The precision check is made by checking the operational flow rate of the analyzer. If a precision flow rate check is made in conjunction with a flow rate adjustment, it must be made prior to such flow rate adjustment. Randomization of the precision check with respect to time of day, day of week, and routine service and adjustments is encouraged where possible.

3.1.2.1 Standard procedure: Use a flow rate transfer standard certified in accordance with section 2.3.3 of this appendix to check the analyzer's normal flow rate. Care should be used in selecting and using the flow rate measurement device such that it does not alter the normal operating flow rate of the analyzer. Report the actual analyzer flow rate measured by the transfer standard and the corresponding flow rate measured, indicated, or assumed by the analyzer.

3.1.2.2 Alternative procedure:

3.1.2.2.1 It is permissible to obtain the precision check flow rate data from the analyzer's internal flow meter without the use of an external flow rate transfer standard, provided that:

3.1.2.2.1.1 The flow meter is audited with an external flow rate transfer standard at least every 6 months.

3.1.2.2.1.2 Records of at least the three most recent flow audits of the instrument's internal flow meter over at least several weeks confirm that the flow meter is stable, verifiable and accurate to $\pm 4\%$.

3.1.2.2.1.3 The instrument and flow meter give no indication of improper operation.

3.1.2.2.2 With suitable communication capability, the precision check may thus be carried out remotely. For this procedure, report the set-point flow rate as the actual flow rate along with the flow rate measured or indicated by the analyzer flow meter.

3.1.2.2.3 For either procedure, the percent differences between the actual and indicated flow rates are used to assess the precision of the monitoring data as described in section 5.1 of this appendix (using flow rates in lieu of concentrations). The percent differences between these concentrations are used to assess the precision of the monitoring data as described in section 5.1. of this appendix.

3.2 Accuracy of Automated Methods Excluding PM_{2.5}.

3.2.1 Methods for SO₂, NO₂, O₃, or CO.

3.2.1.1 Each calendar quarter (during which analyzers are operated), audit at least 25 percent of the SLAMS analyzers that monitor for SO₂, NO₂, O₃, or CO such that each analyzer is audited at least once per year. If

there are fewer than four analyzers for a pollutant within a reporting organization, randomly reaudit one or more analyzers so that at least one analyzer for that pollutant is audited each calendar quarter. Where possible, EPA strongly encourages more frequent auditing, up to an audit frequency of once per quarter for each SLAMS analyzer.

3.2.1.2 (a) The audit is made by challenging the analyzer with at least one audit gas of known concentration (effective concentration for open path analyzers) from each of the following ranges applicable to the analyzer being audited:

Audit Level	Concentration Range, PPM		
	SO ₂ , O ₃	NO ₂	CO
1	0.03–0.08	0.03–0.08	3–8
2	0.15–0.20	0.15–0.20	15–20
3	0.35–0.45	0.35–0.45	35–45
4	0.80–0.90	80–90

(b) NO₂ audit gas for chemiluminescence-type NO₂ analyzers must also contain at least 0.08 ppm NO.

3.2.1.3 NO concentrations substantially higher than 0.08 ppm, as may occur when using some gas phase titration (GPT) techniques, may lead to audit errors in chemiluminescence analyzers due to inevitable minor NO-NO_x channel imbalance. Such errors may be atypical of routine monitoring errors to the extent that such NO concentrations exceed typical ambient NO concentrations at the site. These errors may be minimized by modifying the GPT technique to lower the NO concentrations remaining in the NO₂ audit gas to levels closer to typical ambient NO concentrations at the site.

3.2.1.4 To audit SLAMS analyzers operating on ranges higher than 0 to 1.0 ppm for SO₂, NO₂, and O₃ or 0 to 100 ppm for CO, use audit gases of appropriately higher concentration as approved by the appropriate Regional Administrator or the Administrator's designee. The results of audits at concentration levels other than those shown in the above table need not be reported to EPA.

3.2.1.5 The standards from which audit gas test concentrations are obtained must meet the specifications of section 2.3 of this appendix. The gas standards and equipment used for auditing must not be the same as the standards and equipment used for calibration or calibration span adjustments. The auditor should not be the operator or analyst who conducts the routine monitoring, calibration, and analysis.

3.2.1.6 For point analyzers, the audit shall be carried out by allowing the analyzer to analyze the audit test atmosphere in its normal sampling mode such that the test atmosphere passes through all filters, scrubbers, conditioners, and other sample inlet components used during normal ambient

sampling and as much of the ambient air inlet system as is practicable. The exception provided in section 3.1 of this appendix for certain CO analyzers does not apply for audits.

3.2.1.7 Open path analyzers are audited by inserting a test cell containing the various audit gas concentrations into the optical measurement beam of the instrument. If possible, the normally used transmitter, receiver, and, as appropriate, reflecting devices should be used during the audit, and the normal monitoring configuration of the instrument should be modified as little as possible to accommodate the test cell for the audit. However, if permitted by the associated operation or instruction manual, an alternate local light source or an alternate optical path that does not include the normal atmospheric monitoring path may be used. The actual concentrations of the audit gas in the test cell must be selected to produce effective concentrations in the ranges specified in this section 3.2 of this appendix. Generally, each audit concentration measurement result will be the sum of the atmospheric pollutant concentration and the audit test concentration. If so, the result must be corrected to remove the atmospheric concentration contribution. The corrected concentration is obtained by subtracting the average of the atmospheric concentrations measured by the open path instrument under test immediately before and immediately after the audit test (or preferably before and after each audit concentration level) from the audit concentration measurement. If the difference between the before and after measurements is greater than 20 percent of the effective concentration of the test gas standard, discard the test result for that concentration level and repeat the test for that level. If possible, open path analyzers should be audited during periods when the atmospheric pollutant concentrations are relatively low and steady. Also, the monitoring path length must be reverified to within ±3 percent to validate the audit, since the monitoring path length is critical to the determination of the effective concentration.

3.2.1.8 Report both the actual concentrations (effective concentrations for open path analyzers) of the audit gases and the corresponding concentration measurements (corrected concentrations, if applicable, for open path analyzers) indicated or produced by the analyzer being tested. The percent differences between these concentrations are used to assess the accuracy of the monitoring data as described in section 5.2 of this appendix.

3.2.2 Methods for Particulate Matter Excluding PM_{2.5}.

3.2.2.1 Each calendar quarter, audit the flow rate of at least 25 percent of the SLAMS PM₁₀ analyzers such that each PM₁₀ analyzer is audited at least once per year. If there are

fewer than four PM₁₀ analyzers within a reporting organization, randomly re-audit one or more analyzers so that at least one analyzer is audited each calendar quarter. Where possible, EPA strongly encourages more frequent auditing, up to an audit frequency of once per quarter for each SLAMS analyzer.

3.2.2.2 The audit is made by measuring the analyzer's normal operating flow rate, using a flow rate transfer standard certified in accordance with section 2.3.3 of this appendix. The flow rate standard used for auditing must not be the same flow rate standard used to calibrate the analyzer. However, both the calibration standard and the audit standard may be referenced to the same primary flow rate or volume standard. Great care must be used in auditing the flow rate to be certain that the flow measurement device does not alter the normal operating flow rate of the analyzer. Report the audit (actual) flow rate and the corresponding flow rate indicated or assumed by the sampler. The percent differences between these flow rates are used to calculate accuracy (PM₁₀) as described in section 5.2 of this appendix.

3.3 Precision of Manual Methods Excluding PM_{2.5}.

3.3.1 For each network of manual methods other than for PM_{2.5}, select one or more monitoring sites within the reporting organization for duplicate, collocated sampling as follows: for 1 to 5 sites, select 1 site; for 6 to 20 sites, select 2 sites; and for over 20 sites, select 3 sites. Where possible, additional collocated sampling is encouraged. For purposes of precision assessment, networks for measuring TSP and PM₁₀ shall be considered separately from one another. PM₁₀ and TSP sites having annual mean particulate matter concentrations among the highest 25 percent of the annual mean concentrations for all the sites in the network must be selected or, if such sites are impractical, alternative sites approved by the Regional Administrator may be selected.

3.3.2 In determining the number of collocated sites required for PM₁₀, monitoring networks for lead should be treated independently from networks for particulate matter, even though the separate networks may share one or more common samplers. However, a single pair of samplers collocated at a common-sampler monitoring site that meets the requirements for both a collocated lead site and a collocated particulate matter site may serve as a collocated site for both networks.

3.3.3 The two collocated samplers must be within 4 meters of each other, and particulate matter samplers must be at least 2 meters apart to preclude airflow interference. Calibration, sampling, and analysis must be the same for both collocated samplers and the same as for all other samplers in the network.

3.3.4 For each pair of collocated samplers, designate one sampler as the primary sampler whose samples will be used to report air quality for the site, and designate the other as the duplicate sampler. Each duplicate sampler must be operated concurrently with its associated routine sampler at least once per week. The operation schedule should be selected so that the sampling days are distributed evenly over the year and over the seven days of the week. A six-day sampling schedule is required. Report the measurements from both samplers at each collocated sampling site. The calculations for evaluating precision between the two collocated samplers are described in section 5.3 of this appendix.

3.4 Accuracy of Manual Methods Excluding PM_{2.5}. The accuracy of manual sampling methods is assessed by auditing a portion of the measurement process.

3.4.1 Procedures for PM₁₀ and TSP.

3.4.1.1 Procedures for flow rate audits for PM₁₀. Each calendar quarter, audit the flow rate of at least 25 percent of the PM₁₀ samplers such that each PM₁₀ sampler is audited at least once per year. If there are fewer than four PM₁₀ samplers within a reporting organization, randomly reaudit one or more samplers so that one sampler is audited each calendar quarter. Audit each sampler at its normal operating flow rate, using a flow rate transfer standard certified in accordance with section 2.3.3 of this appendix. The flow rate standard used for auditing must not be the same flow rate standard used to calibrate the sampler. However, both the calibration standard and the audit standard may be referenced to the same primary flow rate standard. The flow audit should be scheduled so as to avoid interference with a scheduled sampling period. Report the audit (actual) flow rate and the corresponding flow rate indicated by the sampler's normally used flow indicator. The percent differences between these flow rates are used to calculate accuracy and bias as described in section 5.4.1 of this appendix.

3.4.1.2 Great care must be used in auditing high-volume particulate matter samplers having flow regulators because the introduction of resistance plates in the audit flow standard device can cause abnormal flow patterns at the point of flow sensing. For this reason, the flow audit standard should be used with a normal filter in place and without resistance plates in auditing flow-regulated high-volume samplers, or other steps should be taken to assure that flow patterns are not perturbed at the point of flow sensing.

3.4.2 SO₂ Methods.

3.4.2.1 Prepare audit solutions from a working sulfite-tetrachloromercurate (TCM) solution as described in section 10.2 of the SO₂ Reference Method (40 CFR part 50, appendix A). These audit samples must be prepared

independently from the standardized sulfite solutions used in the routine calibration procedure. Sulfite-TCM audit samples must be stored between 0 and 5 °C and expire 30 days after preparation.

3.4.2.2 Prepare audit samples in each of the concentration ranges of 0.2-0.3, 0.5-0.6, and 0.8-0.9 µg SO₂/ml. Analyze an audit sample in each of the three ranges at least once each day that samples are analyzed and at least twice per calendar quarter. Report the audit concentrations (in µg SO₂/ml) and the corresponding indicated concentrations (in µg SO₂/ml). The percent differences between these concentrations are used to calculate accuracy as described in section 5.4.2 of this appendix.

3.4.3 NO₂ Methods. Prepare audit solutions from a working sodium nitrite solution as described in the appropriate equivalent method (see reference 8 of this appendix). These audit samples must be prepared independently from the standardized nitrite solutions used in the routine calibration procedure. Sodium nitrite audit samples expire in 3 months after preparation. Prepare audit samples in each of the concentration ranges of 0.2-0.3, 0.5-0.6, and 0.8-0.9 µg NO₂/ml. Analyze an audit sample in each of the three ranges at least once each day that samples are analyzed and at least twice per calendar quarter. Report the audit concentrations (in µg NO₂/ml) and the corresponding indicated concentrations (in µg NO₂/ml). The percent differences between these concentrations are used to calculate accuracy as described in section 5.4.2 of this appendix.

3.4.4 Pb Methods.

3.4.4.1 For the Pb Reference Method (40 CFR part 50, appendix G), the flow rates of the high-volume Pb samplers shall be audited as part of the TSP network using the same procedures described in section 3.4.1 of this appendix. For agencies operating both TSP and Pb networks, 25 percent of the total number of high-volume samplers are to be audited each quarter.

3.4.4.2 Each calendar quarter, audit the Pb Reference Method analytical procedure using glass fiber filter strips containing a known quantity of Pb. These audit sample strips are prepared by depositing a Pb solution on unexposed glass fiber filter strips of dimensions 1.9 cm by 20.3 cm (3/4 inch by 8 inch) and allowing them to dry thoroughly. The audit samples must be prepared using batches of reagents different from those used to calibrate the Pb analytical equipment being audited. Prepare audit samples in the following concentration ranges:

Range	Pb Concentration, µg/Strip	Equivalent Ambient Pb Concentration, µg/m ³ ¹
1	100–300	0.5–1.5

Range	Pb Concentration, µg/Strip	Equivalent Ambient Pb Concentration, µg/m ³ ¹
2	600–1000	3.0–5.0

¹ Equivalent ambient Pb concentration in µg/m³ is based on sampling at 1.7 m³/min for 24 hours on a 20.3 cm×25.4 cm (8 inch×10 inch) glass fiber filter.

3.4.4.3 Audit samples must be extracted using the same extraction procedure used for exposed filters.

3.4.4.4 Analyze three audit samples in each of the two ranges each quarter samples are analyzed. The audit sample analyses shall be distributed as much as possible over the entire calendar quarter. Report the audit concentrations (in µg Pb/strip) and the corresponding measured concentrations (in µg Pb/strip) using unit code 77. The percent differences between the concentrations are used to calculate analytical accuracy as described in section 5.4.2 of this appendix.

3.4.4.5 The accuracy of an equivalent Pb method is assessed in the same manner as for the reference method. The flow auditing device and Pb analysis audit samples must be compatible with the specific requirements of the equivalent method.

3.5 Measurement Uncertainty for Automated and Manual PM_{2.5} Methods. The goal for acceptable measurement uncertainty has been defined as 10 percent coefficient of variation (CV) for total precision and ± 10 percent for total bias (reference 14 of this appendix).

3.5.1 Flow Rate Audits.

3.5.1.1 Automated methods for PM_{2.5}. A one-point precision check must be performed at least once every 2 weeks on each automated analyzer used to measure PM_{2.5}. The precision check is made by checking the operational flow rate of the analyzer. If a precision flow rate check is made in conjunction with a flow rate adjustment, it must be made prior to such flow rate adjustment. Randomization of the precision check with respect to time of day, day of week, and routine service and adjustments is encouraged where possible.

3.5.1.1.1 Standard procedure: Use a flow rate transfer standard certified in accordance with section 2.3.3 of this appendix to check the analyzer's normal flow rate. Care should be used in selecting and using the flow rate measurement device such that it does not alter the normal operating flow rate of the analyzer. Report the actual analyzer flow rate measured by the transfer standard and the corresponding flow rate measured, indicated, or assumed by the analyzer.

3.5.1.1.2 Alternative procedure: It is permissible to obtain the precision check flow rate data from the analyzer's internal flow meter without the use of an external flow rate transfer standard, provided that the flow meter is audited with an external flow rate

transfer standard at least every 6 months; records of at least the three most recent flow audits of the instrument's internal flow meter over at least several weeks confirm that the flow meter is stable, verifiable and accurate to $\pm 4\%$; and the instrument and flow meter give no indication of improper operation. With suitable communication capability, the precision check may thus be carried out remotely. For this procedure, report the set-point flow rate as the actual flow rate along with the flow rate measured or indicated by the analyzer flow meter.

3.5.1.1.3 For either procedure, the differences between the actual and indicated flow rates are used to assess the precision of the monitoring data as described in section 5.5 of this appendix.

3.5.1.2 Manual methods for $PM_{2.5}$. Each calendar quarter, audit the flow rate of each SLAMS $PM_{2.5}$ analyzer. The audit is made by measuring the analyzer's normal operating flow rate, using a flow rate transfer standard certified in accordance with section 2.3.3 of this appendix. The flow rate standard used for auditing must not be the same flow rate standard used to calibrate the analyzer. However, both the calibration standard and the audit standard may be referenced to the same primary flow rate or volume standard. Great care must be used in auditing the flow rate to be certain that the flow measurement device does not alter the normal operating flow rate of the analyzer. Report the audit (actual) flow rate and the corresponding flow rate indicated or assumed by the sampler. The procedures used to calculate measurement uncertainty $PM_{2.5}$ are described in section 5.5 of this appendix.

3.5.2 Measurement of Precision using Collocated Procedures for Automated and Manual Methods of $PM_{2.5}$.

(a) For $PM_{2.5}$ sites within a reporting organization each EPA designated Federal reference method (FRM) or Federal equivalent method (FEM) must:

(1) Have 25 percent of the monitors collocated (values of .5 and greater round up).

(2) Have at least 1 collocated monitor (if the total number of monitors is less than 4). The first collocated monitor must be a designated FRM monitor.

(b) In addition, monitors selected must also meet the following requirements:

(1) A monitor designated as an EPA FRM shall be collocated with a monitor having the same EPA FRM designation.

(2) For each monitor designated as an EPA FEM, 50 percent of the designated monitors shall be collocated with a monitor having the same method designation and 50 percent of the monitors shall be collocated with an FRM monitor. If there are an odd number of collocated monitors required, the additional monitor shall be an FRM. An example of this procedure is found in table A-2 of this appendix.

(c) For $PM_{2.5}$ sites during the initial deployment of the SLAMS network, special emphasis should be placed on those sites in areas likely to be in violation of the NAAQS. Once areas are initially determined to be in violation, the collocated monitors should be deployed according to the following protocol:

(1) Eighty percent of the collocated monitors should be deployed at sites with concentrations \geq ninety percent of the annual $PM_{2.5}$ NAAQS (or 24-hour NAAQS if that is affecting the area); one hundred percent if all sites have concentrations above either NAAQS, and each area determined to be in violation should be represented by at least one collocated monitor.

(2) The remaining 20 percent of the collocated monitors should be deployed at sites with concentrations $<$ ninety percent of the annual $PM_{2.5}$ NAAQS (or 24-hour NAAQS if that is affecting the area)

(3) If an organization has no sites at concentration ranges \geq ninety percent of the annual $PM_{2.5}$ NAAQS (or 24-hour NAAQS if that is affecting the area), 60 percent of the collocated monitors should be deployed at those sites with the annual mean $PM_{2.5}$ concentrations (or 24-hour NAAQS if that is affecting the area) among the highest 25 percent for all $PM_{2.5}$ sites in the network.

3.5.2.1 In determining the number of collocated sites required for $PM_{2.5}$, monitoring networks for visibility should not be treated independently from networks for particulate matter, as the separate networks may share one or more common samplers. However, for class I visibility areas, EPA will accept visibility aerosol mass measurement instead of a $PM_{2.5}$ measurement if the latter measurement is unavailable. Any $PM_{2.5}$ monitoring site which does not have a monitor which is an EPA federal reference or equivalent method is not required to be included in the number of sites which are used to determine the number of collocated monitors.

3.5.2.2 The two collocated samples must be within 4 meters of each other, and particulate matter samplers must be at least 2 meters apart (1 meter apart for samplers having flow rates less than 200 liters/min.) to preclude airflow interference. Calibration, sampling, and analysis must be the same for both collocated samplers and the same as for all other samplers in the network.

3.5.2.3 For each pair of collocated samplers, designate one sampler as the primary sampler whose samples will be used to report air quality for the site, and designate the other as the duplicate sampler. Each duplicate sampler must be operated concurrently with its associated primary sampler. The operation schedule should be selected so that the sampling days are distributed evenly over the year and over the 7 days of the week and therefore, a 6-day sampling schedule is required. Report the measurements from both samplers at each collocated sampling site.

The calculations for evaluating precision between the two collocated samplers are described in section 5.5 of this appendix.

3.5.3 Measurement of Bias using the FRM Audit Procedures for Automated and Manual Methods of PM_{2.5}.

3.5.3.1 The FRM audit is an independent assessment of the total measurement system bias. These audits will be performed under the National Performance Audit Program (section 2.4 of this appendix) or a comparable program. Twenty-five percent of the SLAMS monitors within each reporting organization will be assessed with an FRM audit each year. Additionally, every designated FRM or FEM within a reporting organization must:

(a) Have at least 25 percent of each method designation audited, including collocated sites (even those collocated with FRM instruments), (values of .5 and greater round up).

(b) Have at least one monitor audited.

(c) Be audited at a frequency of four audits per year.

(d) Have all FRM or FEM samplers subject to an FRM audit at least once every 4 years. Table A-2 illustrates the procedure mentioned above.

3.5.3.2 For PM_{2.5} sites during the initial deployment of the SLAMS network, special emphasis should be placed on those sites in areas likely to be in violation of the NAAQS. Once areas are initially determined to be in violation, the FRM audit program should be implemented according to the following protocol:

(a) Eighty percent of the FRM audits should be deployed at sites with concentrations \geq ninety percent of the annual PM_{2.5} NAAQS (or 24-hour NAAQS if that is affecting the area); one hundred percent if all sites have concentrations above either NAAQS, and each area determined to be in violation should implement an FRM audit at a minimum of one monitor within that area.

(b) The remaining 20 percent of the FRM audits should be implemented at sites with concentrations $<$ ninety percent of the annual PM_{2.5} NAAQS (or 24-hour NAAQS if that is affecting the area).

(c) If an organization has no sites at concentration ranges \geq ninety percent of the annual PM_{2.5} NAAQS (or 24-hour NAAQS if that is affecting the area), 60 percent of the FRM audits should be implemented at those sites with the annual mean PM_{2.5} concentrations (or 24-hour NAAQS if that is affecting the area) among the highest 25 percent for all PM_{2.5} sites in the network. Additional information concerning the FRM audit program is contained in reference 7 of this appendix. The calculations for evaluating bias between the primary monitor and the FRM audit are described in section 5.5.

4. Reporting Requirements.

(a) For each pollutant, prepare a list of all monitoring sites and their AIRS site identi-

fication codes in each reporting organization and submit the list to the appropriate EPA Regional Office, with a copy to AIRS-AQS. Whenever there is a change in this list of monitoring sites in a reporting organization, report this change to the Regional Office and to AIRS-AQS.

4.1 Quarterly Reports. For each quarter, each reporting organization shall report to AIRS-AQS directly (or via the appropriate EPA Regional Office for organizations not direct users of AIRS) the results of all valid precision, bias and accuracy tests it has carried out during the quarter. The quarterly reports of precision, bias and accuracy data must be submitted consistent with the data reporting requirements specified for air quality data as set forth in §58.35(c). EPA strongly encourages early submittal of the QA data in order to assist the State and Local agencies in controlling and evaluating the quality of the ambient air SLAMS data. Each organization shall report all QA/QC measurements. Report results from invalid tests, from tests carried out during a time period for which ambient data immediately prior or subsequent to the tests were invalidated for appropriate reasons, and from tests of methods or analyzers not approved for use in SLAMS monitoring networks under appendix C of this part. Such data should be flagged so that it will not be utilized for quantitative assessment of precision, bias and accuracy.

4.2 Annual Reports.

4.2.1 When precision, bias and accuracy estimates for a reporting organization have been calculated for all four quarters of the calendar year, EPA will calculate and report the measurement uncertainty for the entire calendar year. These limits will then be associated with the data submitted in the annual SLAMS report required by § 58.26.

4.2.2 Each reporting organization shall submit, along with its annual SLAMS report, a listing by pollutant of all monitoring sites in the reporting organization.

5. Calculations for Data Quality Assessment.

(a) Calculations of measurement uncertainty are carried out by EPA according to the following procedures. Reporting organizations should report the data for individual precision, bias and accuracy tests as specified in sections 3 and 4 of this appendix even though they may elect to perform some or all of the calculations in this section on their own.

5.1 Precision of Automated Methods Excluding PM_{2.5}. Estimates of the precision of automated methods are calculated from the results of biweekly precision checks as specified in section 3.1 of this appendix. At the end of each calendar quarter, an integrated precision probability interval for all SLAMS analyzers in the organization is calculated for each pollutant.

5.1.1 Single Analyzer Precision.

5.1.1.1 The percent difference (d_i) for each precision check is calculated using equation 1, where Y_i is the concentration indicated by the analyzer for the i -th precision check and X_i is the known concentration for the i -th precision check, as follows:

Equation 1

$$d_i = \frac{Y_i - X_i}{X_i} \times 100$$

5.1.1.2 For each analyzer, the quarterly average (d_j) is calculated with equation 2, and the standard deviation (S_j) with equation 3, where n is the number of precision checks on the instrument made during the calendar quarter. For example, n should be 6 or 7 if precision checks are made biweekly during a quarter. Equation 2 and 3 follow:

Equation 2

$$d_j = \frac{1}{n} \sum_{i=1}^n d_i$$

Equation 3

$$S_j = \sqrt{\frac{1}{n-1} \left[\sum_{i=1}^n d_i^2 - \frac{1}{n} \left(\sum_{i=1}^n d_i \right)^2 \right]}$$

5.1.2.2 Equations 4 and 5 are used when the same number of precision checks are made for each analyzer. Equations 4a and 5a are used to obtain a weighted average and a weighted standard deviation when different numbers of precision checks are made for the analyzers.

5.1.2.3 For each pollutant, the 95 Percent Probability Limits for the precision of a reporting organization are calculated using equations 6 and 7, as follows:

Equation 6

Upper 95 Percent Probability

$$\text{Limit} = D + 1.96 S_a$$

5.1.2 Precision for Reporting Organization.

5.1.2.1 For each pollutant, the average of averages (D) and the pooled standard deviation (S_a) are calculated for all analyzers audited for the pollutant during the quarter, using either equations 4 and 5 or 4a and 5a, where k is the number of analyzers audited within the reporting organization for a single pollutant, as follows:

Equation 4

$$D = \frac{1}{k} \sum_{j=1}^k d_j$$

Equation 4a

$$D = \frac{n_1 d_1 + n_2 d_2 + \dots + n_j d_j + \dots + n_k d_k}{n_1 + n_2 + \dots + n_j + \dots + n_k}$$

Equation 5

$$S_a = \sqrt{\frac{1}{k} \sum_{j=1}^k S_j^2}$$

Equation 5a

$$S_a = \sqrt{\frac{(n_1 - 1)S_1^2 + (n_2 - 1)S_2^2 + \dots + (n_j - 1)S_j^2 + \dots + (n_k - 1)S_k^2}{n_1 + n_2 + \dots + n_j + \dots + n_k - k}}$$

Equation 7

Lower 95 Percent Probability

$$\text{Limit} = D - 1.96 S_a$$

5.2 Accuracy of Automated Methods Excluding $PM_{2.5}$. Estimates of the accuracy of automated methods are calculated from the results of independent audits as described in section 3.2 of this appendix. At the end of each calendar quarter, an integrated accuracy probability interval for all SLAMS analyzers audited in the reporting organization is calculated for each pollutant. Separate probability limits are calculated for each audit concentration level in section 3.2 of this appendix.

5.2.1 Single Analyzer Accuracy. The percentage difference (d_i) for each audit concentration is calculated using equation 1,

where Y_i is the analyzer's indicated concentration measurement from the i -th audit check and X_i is the actual concentration of the audit gas used for the i -th audit check.

5.2.2 Accuracy for Reporting Organization.

5.2.2.1 For each audit concentration level of a particular pollutant, the average (D) of the individual percentage differences (d_i) for all n analyzers audited during the quarter is calculated using equation 8, as follows:

Equation 8

$$D = \frac{1}{n} \sum_{i=1}^n d_i$$

5.2.2.2 For each concentration level of a particular pollutant, the standard deviation (S_a) of all the individual percentage differences for all n analyzers audited during the quarter is calculated, using equation 9, as follows:

Equation 9

$$S_a = \sqrt{\frac{1}{n-1} \left[\sum_{i=1}^n d_i^2 - \frac{1}{n} \left(\sum_{i=1}^n d_i \right)^2 \right]}$$

5.2.2.3 For reporting organizations having four or fewer analyzers for a particular pollutant, only one audit is required each quarter. For such reporting organizations, the audit results of two consecutive quarters are required to calculate an average and a standard deviation, using equations 8 and 9. Therefore, the reporting of probability limits shall be on a semiannual (instead of a quarterly) basis.

5.2.2.4 For each pollutant, the 95 Percent Probability Limits for the accuracy of a reporting organization are calculated at each audit concentration level using equations 6 and 7.

5.3 Precision of Manual Methods Excluding $PM_{2.5}$. Estimates of precision of manual methods are calculated from the results obtained from collocated samplers as described in section 3.3 of this appendix. At the end of each calendar quarter, an integrated precision probability interval for all collocated samplers operating in the reporting organization is calculated for each manual method network.

5.3.1 Single Sampler Precision.

5.3.1.1 At low concentrations, agreement between the measurements of collocated samplers, expressed as percent differences, may be relatively poor. For this reason, collocated measurement pairs are selected for use in the precision calculations only when both measurements are above the following limits:

(a) TSP: 20 $\mu\text{g}/\text{m}^3$.

(b) SO_2 : 45 $\mu\text{g}/\text{m}^3$.

(c) NO_2 : 30 $\mu\text{g}/\text{m}^3$.

(d) Pb: 0.15 $\mu\text{g}/\text{m}^3$.

(e) PM_{10} : 20 $\mu\text{g}/\text{m}^3$.

5.3.1.2 For each selected measurement pair, the percent difference (d_i) is calculated, using equation 10, as follows:

Equation 10

$$d_i = \frac{Y_i - X_i}{(Y_i + X_i)/2} \times 100$$

where:

Y_i is the pollutant concentration measurement obtained from the duplicate sampler; and

X_i is the concentration measurement obtained from the primary sampler designated for reporting air quality for the site.

(a) For each site, the quarterly average percent difference (d_i) is calculated from equation 2 and the standard deviation (S_i) is calculated from equation 3, where n = the number of selected measurement pairs at the site.

5.3.2 Precision for Reporting Organization.

5.3.2.1 For each pollutant, the average percent difference (D) and the pooled standard deviation (S_a) are calculated, using equations 4 and 5, or using equations 4a and 5a if different numbers of paired measurements are obtained at the collocated sites. For these calculations, the k of equations 4, 4a, 5 and 5a is the number of collocated sites.

5.3.2.2 The 95 Percent Probability Limits for the integrated precision for a reporting organization are calculated using equations 11 and 12, as follows:

Equation 11

Upper 95 Percent Probability

$$\text{Limit} = D + 1.96 S_a$$

Equation 12

Lower 95 Percent Probability

$$\text{Limit} = D - 1.96 S_a$$

5.4 Accuracy of Manual Methods Excluding $PM_{2.5}$. Estimates of the accuracy of manual methods are calculated from the results of independent audits as described in section 3.4 of this appendix. At the end of each calendar quarter, an integrated accuracy probability interval is calculated for each manual method network operated by the reporting organization.

5.4.1 Particulate Matter Samplers other than $PM_{2.5}$ (including reference method Pb samplers).

5.4.1.1 Single Sampler Accuracy. For the flow rate audit described in section 3.4.1 of this appendix, the percentage difference (d_i) for each audit is calculated using equation 1, where X_i represents the known flow rate and Y_i represents the flow rate indicated by the sampler.

5.4.1.2 Accuracy for Reporting Organization. For each type of particulate matter measured (e.g., TSP/Pb), the average (D) of the individual percent differences for all similar particulate matter samplers audited during the calendar quarter is calculated using equation 8. The standard deviation (S_a) of the percentage differences for all of the similar particulate matter samplers audited during the calendar quarter is calculated using equation 9. The 95 Percent Probability Limits for the integrated accuracy for the reporting organization are calculated using equations 6 and 7. For reporting organizations having four or fewer particulate matter samplers of one type, only one audit is required each quarter, and the audit results of two consecutive quarters are required to calculate an average and a standard deviation. In that case, probability limits shall be reported semi-annually rather than quarterly.

5.4.2 Analytical Methods for SO_2 , NO_2 , and Pb.

5.4.2.1 Single Analysis-Day Accuracy. For each of the audits of the analytical methods for SO_2 , NO_2 , and Pb described in sections 3.4.2, 3.4.3, and 3.4.4 of this appendix, the percentage difference (d_j) at each concentration level is calculated using equation 1, where X_j represents the known value of the audit sample and Y_j represents the value of SO_2 , NO_2 , or Pb indicated by the analytical method.

5.4.2.2 Accuracy for Reporting Organization. For each analytical method, the average (D) of the individual percent differences at each concentration level for all audits during the calendar quarter is calculated using equation 8. The standard deviation (S_a) of the percentage differences at each concentration level for all audits during the calendar quarter is calculated using equation 9. The 95 Percent Probability Limits for the accuracy for the reporting organization are calculated using equations 6 and 7.

5.5 Precision, Accuracy and Bias for Automated and Manual $PM_{2.5}$ Methods.

(a) Reporting organizations are required to report the data that will allow assessments of the following individual quality control checks and audits:

- (1) Flow rate audit.
- (2) Collocated samplers, where the duplicate sampler is not an FRM device.
- (3) Collocated samplers, where the duplicate sampler is an FRM device.
- (4) FRM audits.

(b) EPA uses the reported results to derive precision, accuracy and bias estimates according to the following procedures.

5.5.1 Flow Rate Audits. The reporting organization shall report both the audit standard flow rate and the flow rate indicated by the sampling instrument. These results are used by EPA to calculate flow rate accuracy and bias estimates.

5.5.1.1 Accuracy of a Single Sampler - Single Check (Quarterly) Basis (d_i). The percentage difference (d_i) for a single flow rate audit d_i is calculated using equation 13, where X_i represents the audit standard flow rate (known) and Y_i represents the indicated flow rate, as follows:

Equation 13

$$d_i = \frac{Y_i - X_i}{X_i} \times 100$$

5.5.1.2 Bias of a Single Sampler - Annual Basis (D_j). For an individual particulate sampler j , the average (D_j) of the individual percentage differences (d_i) during the calendar year is calculated using equation 14, where n_j is the number of individual percentage differences produced for sampler j during the calendar year, as follows:

Equation 14

$$D_j = \frac{1}{n_j} \times \sum_{i=1}^{n_j} d_i$$

5.5.1.3 Bias for Each EPA Federal Reference and Equivalent Method Designation Employed by Each Reporting Organization - Quarterly Basis ($D_{k,q}$). For method designation k used by the reporting organization, quarter q 's single sampler percentage differences (d_i) are averaged using equation 16, where $n_{k,q}$ is the number of individual percentage differences produced for method designation k in quarter q , as follows:

Equation 15

$$D_{k,q} = \frac{1}{n_{k,q}} \times \sum_{i=1}^{n_{k,q}} d_i$$

5.5.1.4 Bias for Each Reporting Organization - Quarterly Basis (D_q). For each reporting organization, quarter q 's single sampler percentage differences (d_i) are averaged using equation 16, to produce a single average for each reporting organization, where n_q is the total number of single sampler percentage differences for all federal reference or equivalent methods of samplers in quarter q , as follows:

Equation 16

$$D_q = \frac{1}{n_q} \times \sum_{i=1}^{n_q} d_i$$

5.5.1.5 Bias for Each EPA Federal Reference and Equivalent Method Designation Employed by Each Reporting Organization - Annual Basis (D_k). For method designation k used by the reporting organization, the annual average percentage difference, D_k , is derived using equation 17, where $D_{k,q}$ is the average reported for method designation k during the q th quarter, and $n_{k,q}$ is the number of the method designation k 's monitors that were deployed during the q th quarter, as follows:

Equation 17

$$D_k = \frac{\sum_{q=1}^4 (n_{k,q} D_{k,q})}{\sum_{q=1}^4 n_{k,q}}$$

5.5.1.6 Bias for Each Reporting Organization - Annual Basis (D). For each reporting organization, the annual average percentage difference, D , is derived using equation 18, where D_q is the average reported for the reporting organization during the q th quarter, and n_q is the total number monitors that were deployed during the q th quarter. A single annual average is produced for each reporting organization. Equation 18 follows:

Equation 18

$$D = \frac{\sum_{q=1}^4 (n_q D_q)}{\sum_{q=1}^4 n_q}$$

5.5.2 Collocated Samplers, Where the Duplicate Sampler is not an FRM Device. (a) At low concentrations, agreement between the measurements of collocated samplers may be relatively poor. For this reason, collocated measurement pairs are selected for use in the precision calculations only when both measurements are above the following limits:

$$PM_{2.5} : 6 \mu g/m^3$$

(b) Collocated sampler results are used to assess measurement system precision. A collocated sampler pair consists of a primary sampler (used for routine monitoring) and a

duplicate sampler (used as a quality control check). Quarterly precision estimates are calculated by EPA for each pair of collocated samplers and for each method designation employed by each reporting organization. Annual precision estimates are calculated by EPA for each primary sampler, for each EPA Federal reference method and equivalent method designation employed by each reporting organization, and nationally for each EPA Federal reference method and equivalent method designation.

5.5.2.1 Percent Difference for a Single Check (d_i). The percentage difference, d_i , for each check is calculated by EPA using equation 19, where X_i represents the concentration produced from the primary sampler and Y_i represents concentration reported for the duplicate sampler, as follows:

Equation 19

$$d_i = \frac{Y_i - X_i}{(Y_i + X_i)/2} \times 100$$

5.5.2.2 Coefficient of Variation (CV) for a Single Check (CV_i). The coefficient of variation, CV_i , for each check is calculated by EPA by dividing the absolute value of the percentage difference, d_i , by the square root of two as shown in equation 20, as follows:

Equation 20

$$CV_i = \frac{|d_i|}{\sqrt{2}}$$

5.5.2.3 Precision of a Single Sampler - Quarterly Basis ($CV_{j,q}$).

(a) For particulate sampler j , the individual coefficients of variation ($CV_{j,q}$) during the quarter are pooled using equation 21, where $n_{j,q}$ is the number of pairs of measurements from collocated samplers during the quarter, as follows:

Equation 21

$$CV_{j,q} = \sqrt{\frac{\sum_{i=1}^{n_{j,q}} CV_i^2}{n_{j,q}}}$$

(b) The 90 percent confidence limits for the single sampler's CV are calculated by EPA using equations 22 and 23, where $X^2_{0.05,df}$ and $X^2_{0.95,df}$ are the 0.05 and 0.95 quantiles of the chi-square (X^2) distribution with $n_{j,q}$ degrees of freedom, as follows:

Equation 22

$$\text{Lower Confidence Limit} = CV_{j,q} \sqrt{\frac{n_{j,q}}{\chi^2_{0.95, n_{j,q}}}}$$

Equation 23

$$\text{Upper Confidence Limit} = CV_{j,q} \sqrt{\frac{n_{j,q}}{\chi^2_{0.05, n_{j,q}}}}$$

5.5.2.4 Precision of a Single Sampler - Annual Basis. For particulate sampler j, the individual coefficients of variation, $CV_{j,i}$, produced during the calendar year are pooled using equation 21, where n_j is the number of checks made during the calendar year. The 90 percent confidence limits for the single sampler's CV are calculated by EPA using equations 22 and 23, where $\chi^2_{0.05, df}$ and $\chi^2_{0.95, df}$ are the 0.05 and 0.95 quantiles of the chi-square (χ^2) distribution with n_j degrees of freedom.

5.5.2.5 Precision for Each EPA Federal Reference Method and Equivalent Method Designation Employed by Each Reporting Organization - Quarterly Basis ($CV_{k,q}$).

(a) For each method designation k used by the reporting organization, the quarter's single sampler coefficients of variation, $CV_{j,q}$ s, obtained from equation 21, are pooled using equation 24, where $n_{k,q}$ is the number of collocated primary monitors for the designated method (but not collocated with FRM samplers) and $n_{j,q}$ is the number of degrees of freedom associated with $CV_{j,q}$, as follows:

Equation 24

$$CV_{k,q} = \sqrt{\frac{\sum_{j=1}^{n_{k,q}} (CV_{j,q}^2 n_{j,q})}{\sum_{j=1}^{n_{k,q}} n_{j,q}}}$$

(b) The number of method CVs produced for a reporting organization will equal the number of different method designations having more than one primary monitor employed by the organization during the quarter. (When exactly one monitor of a specified designation is used by a reporting organization, it will be collocated with an FRM sampler.)

5.5.2.6 Precision for Each Method Designation Employed by Each Reporting Organization - Annual Basis (CV_k). For each method designation k used by the reporting organization, the quarterly estimated coefficients of variation, $CV_{k,q}$, are pooled using equation 25, where $n_{k,q}$ is the number of collocated pri-

mary monitors for the designated method during the qth quarter and also the number of degrees of freedom associated with the quarter's precision estimate for the method designation, $CV_{k,q}$, as follows:

Equation 25

$$CV_k = \sqrt{\frac{\sum_{q=1}^4 (CV_{k,q}^2 n_{k,q})}{\sum_{q=1}^4 n_{k,q}}}$$

5.5.3 Collocated Samplers. Where the Duplicate Sampler is an FRM Device. At low concentrations, agreement between the measurements of collocated samplers may be relatively poor. For this reason, collocated measurement pairs are selected for use in the precision calculations only when both measurements are above the following limits: $PM_{2.5}$: 6 $\mu\text{g}/\text{m}^3$. These duplicate sampler results are used to assess measurement system bias. Quarterly bias estimates are calculated by EPA for each primary sampler and for each method designation employed by each reporting organization. Annual precision estimates are calculated by EPA for each primary monitor, for each method designation employed by each reporting organization, and nationally for each method designation.

5.5.3.1 Accuracy for a Single Check (d'_i). The percentage difference, d'_i , for each check is calculated by EPA using equation 26, where X_i represents the concentration produced from the FRM sampler taken as the true value and Y_i represents concentration reported for the primary sampler, as follows:

Equation 26

$$d'_i = \frac{Y_i - X_i}{X_i} \times 100\%$$

5.5.3.2 Bias of a Single Sampler - Quarterly Basis ($D'_{j,q}$).

(a) For particulate sampler j, the average of the individual percentage differences during the quarter q is calculated by EPA using equation 27, where $n_{j,q}$ is the number of checks made for sampler j during the calendar quarter, as follows:

Equation 27

$$D'_{j,q} = \frac{1}{n_{j,q}} \times \sum_{i=1}^{n_{j,q}} d'_i$$

(b) The standard error, $s'_{j,q}$, of sampler j 's percentage differences for quarter q is calculated using equation 28, as follows:

Equation 28

$$s'_{j,q} = \sqrt{\frac{1}{n_{j,q} - 1} \times \left[\left(\sum_{i=1}^{n_{j,q}} d_i^2 \right) - (n_{j,q} D_{j,q}^2) \right] \times \frac{1}{n_{j,q}}}$$

(c) The 95 Percent Confidence Limits for the single sampler's bias are calculated using equations 29 and 30 where $t_{0.975,df}$ is the 0.975 quantile of Student's t distribution with $df = n_{j,q} - 1$ degrees of freedom, as follows:

Equation 29

$$\text{Lower Confidence Limit} = D'_{j,q} - t_{0.975,df} \times s'_{j,q}$$

Equation 30

$$\text{Upper Confidence Limit} = D'_{j,q} + t_{0.975,df} \times s'_{j,q}$$

5.5.3.3 Bias of a Single Sampler - Annual Basis (D'_j).

(a) For particulate sampler j , the mean bias for the year is derived from the quarterly bias estimates, $D'_{j,q}$, using equation 31, where the variables are as defined for equations 27 and 28, as follows:

Equation 31

$$D'_j = \frac{\sum_{q=1}^4 (n_{j,q} D'_{j,q})}{\sum_{q=1}^4 n_{j,q}}$$

(b) The standard error of the above estimate, se'_j is calculated using equation 32, as follows:

Equation 32

$$se'_j = \sqrt{\frac{\sum_{q=1}^4 [s'_{j,q} 2 \times (n_{j,q} - 1)]}{\sum_{q=1}^4 (n_{j,q} - 1) \sum_{q=1}^4 (n_{j,q})}}$$

(c) The 95 Percent Confidence Limits for the single sampler's bias are calculated using equations 33 and 34, where $t_{0.975,df}$ is the 0.975 quantile of Student's t distribution

with $df = (n_{j,1} + n_{j,2} + n_{j,3} + n_{j,4} - 4)$ degrees of freedom, as follows:

Equation 33

$$\text{Lower Confidence Limit} = D'_j - t_{0.975,df} \times se'_j$$

Equation 34

$$\text{Upper Confidence Limit} = D'_j + t_{0.975,df} \times se'_j$$

5.5.3.4 Bias for a Single Reporting Organization (D') - Annual Basis. The reporting organizations mean bias is calculated using equation 35, where variables are as defined in equations 31 and 32, as follows:

Equation 35

$$D' = \frac{1}{n_j} \times \sum_{i=1}^{n_j} D'_j$$

5.5.4 FRM Audits. FRM Audits are performed once per quarter for selected samplers. The reporting organization reports concentration data from the primary sampler. Calculations for FRM Audits are similar to those for collocated samplers having FRM samplers as duplicates. The calculations differ because only one check is performed per quarter.

5.5.4.1 Accuracy for a Single Sampler, Quarterly Basis (d_i). The percentage difference, d_i , for each check is calculated using equation 26, where X_i represents the concentration produced from the FRM sampler and Y_i represents the concentration reported for the primary sampler. For quarter q , the bias estimate for sampler j is denoted $D_{j,q}$.

5.5.4.2 Bias of a Single Sampler - Annual Basis (D'_j). For particulate sampler j , the mean bias for the year is derived from the quarterly bias estimates, $D_{j,q}$, using equation 31, where $n_{j,q}$ equals 1 because one FRM audit is performed per quarter.

5.5.4.3. Bias for a Single Reporting Organization - Annual Basis (D'). The reporting organizations mean bias is calculated using equation 35, where variables are as defined in equations 31 and 32.

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TABLE A–1 TO APPENDIX A—MINIMUM DATA ASSESSMENT REQUIREMENTS

Method	Assessment Method	Coverage	Minimum Frequency	Parameters Reported
Precision: Automated Methods for SO ₂ , NO ₂ , O ₃ , and CO	Response check at concentration between .08 and .10 ppm (8 & 10 ppm for CO) ²	Each analyzer	Once per 2 weeks	Actual concentration ² and measured concentration ³

TABLE A-1 TO APPENDIX A—MINIMUM DATA ASSESSMENT REQUIREMENTS—Continued

Method	Assessment Method	Coverage	Minimum Frequency	Parameters Reported
Manual Methods: All methods except PM _{2.5}	Collocated samplers	1 site for 1–5 sites 2 sites for 6–20 sites 3 sites >20 sites (sites with highest conc.)	Once every six days	Particle mass concentration indicated by sampler and by collocated sampler
Accuracy: Automated Methods for SO ₂ , NO ₂ , O ₃ , and CO	Response check at .03–.08 ppm ^{1,2} .15–.20 ppm ^{1,2} .35–.45 ppm ^{1,2} 80–.90 ppm ^{1,2} (if applicable)	1. Each analyzer 2. 25% of analyzers (at least 1)	1. Once per year 2. Each calendar quarter	Actual concentration ² and measured (indicated) concentration ³ for each level
Manual Methods for SO ₂ and NO ₂	Check of analytical procedure with audit standard solutions	Analytical system	Each day samples are analyzed, at least twice per quarter	Actual concentration and measured (indicated) concentration for each audit solution
TSP, PM ₁₀	Check of sampler flow rate	1. Each sampler 2. 25% of samplers (at least 1)	1. Once per year 2. Each calendar quarter	Actual flow rate and flow rate indicated by the sampler
Lead	1. Check of sample flow rate as for TSP 2. Check of analytical system with Pb audit strips	1. Each sampler 2. Analytical system	1. Include with TSP 2. Each quarter	1. Same as for TSP 2. Actual concentration and measured (indicated) concentration of audit samples (µg Pb/strip)
PM _{2.5} Manual and Automated Methods-Precision	Collocated samplers	25% of SLAMS (monitors with Conc affecting NAAQS violation status)	Once every six days	1. Particle mass concentration indicated by sampler and by collocated sampler 2. 24-hour value for automated methods
Manual and Automated Methods-Accuracy and Bias	1. Check of sampler flow rate 2. Audit with reference method	Every SLAMS monitor	1. Automated—once every 2 weeks; Manual—each calendar quarter (4/year) 2. Minimum 4 measurements per year	1. Actual flow rate and flow rate indicated by sampler 2. Particle mass concentration indicated by sampler and by audit reference sampler

¹ Concentration times 100 for CO.² Effective concentration for open path analyzers.³ Corrected concentration, if applicable, for open path analyzers.TABLE A-2 TO APPENDIX A—SUMMARY OF PM_{2.5} COLLOCATION AND AUDITS PROCEDURES AS AN EXAMPLE OF A TYPICAL REPORTING ORGANIZATION NEEDING 43 MONITORS, HAVING PROCURED FRMs AND THREE OTHER EQUIVALENT METHOD TYPES

Method Designation	Total # of Monitors	Total # Collocated	# of Collocated FRMs	# of Collocated Monitors of Same Type	# of Independent FRM Audits
FRM	25	6	6	n/a	6
Type A	10	3	2	1	3
Type C	2	1	1	0	1
Type D	6	2	1	1	2

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